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Original Article

Distal Tibial Fracture Managed by Circular External Fixation: Clinical and Functional Outcomes

Muhammad Saeed*[1], Muhammad Inam[2], Shafi Ul Haq[1], Israr Ahmad[1].

[1] Orthopedic and Spine Unit, Hayatabad Medical Complex, Peshawar

[2] Orthopedic Department, Lady Reading Hospital, Peshawar, Pakistan

Corresponding author: dr.saeed2600@gmail.com

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Abstract

Background: Distal tibial fractures, often resulting from high-energy trauma, pose significant challenges in orthopedic management due to their complexity and associated soft tissue injuries. Circular external fixation, particularly the Ilizarov technique, has emerged as a treatment option that offers the potential for enhanced fracture stability and preservation of soft tissue integrity.

Objective: To evaluate the functional and clinical outcomes of distal tibial fractures managed by circular external fixation using the Ilizarov technique.

Methods: This prospective study was conducted from September 2023 to May 2024 at the Department of Orthopedics, Hayatabad Medical Complex, Peshawar. Sixty patients aged 18 years or older with distal tibial fractures were included. Patients with diabetes, pregnancy, or age over 60 years were excluded. The fractures were treated using the Ilizarov fixator technique by an experienced surgeon. Postoperative assessments included functional outcomes using the Association for the Study and Application of Methods of Ilizarov (ASAMI) criteria and pain evaluation using the Visual Analog Scale (VAS). Radiographic assessments were performed to evaluate malunion and nonunion. Data were analyzed using SPSS version 25, with descriptive statistics summarizing demographic data and paired t-tests used for comparing preoperative and postoperative pain scores, with significance set at $p < 0.05$.

Results: The mean age of the patients was 41.10 ± 12.74 years, with a mean BMI of 25.07 ± 1.88 kg/m². Males constituted 76.7% of the cohort. The majority of injuries were due to road accidents (51.7%). Functional outcomes showed that 63.3% of patients had excellent results, 18.3% had good outcomes, 15.0% had fair outcomes, and 3.3% had poor outcomes. A significant reduction in pain was observed, with the mean VAS score decreasing from 7.47 ± 0.999 preoperatively to 2.47 ± 0.982 postoperatively ($p = 0.0001$). Complications were minimal, with 13.3% experiencing infections, 1.7% malunion, and 3.3% nonunion.

Conclusion: Circular external fixation using the Ilizarov technique for distal tibial fractures led to favorable clinical and functional outcomes, with significant pain reduction and minimal complications. This technique should be considered a viable option for managing complex distal tibial fractures, particularly in cases requiring soft tissue preservation.

1 Introduction

Distal tibial fractures primarily occur due to significant forceful trauma and are often accompanied by fibular fractures and extensive injury to the surrounding soft tissues. The tibia, being one of the most frequently fractured long bones in the human body, has a distal fracture rate of approximately 0.7%, representing around 10-13% of total tibial fractures (1,2). These fractures are particularly challenging due to their complex nature, often resulting from high-energy mechanisms such as motor vehicle accidents, which are the leading cause of such injuries (3). The complexity of distal tibial fractures is further compounded by their association with fibular fractures, which necessitates a careful and strategic approach to treatment. Typically, management involves first addressing the fibula to achieve adequate length and stability, followed by the anatomical reconstruction of the articular surface and treatment of the tibial pilon fracture through osteosynthesis (4). In cases of comminuted fibular fractures, some authors advocate for initial tibial ORIF (open reduction and internal fixation) due to the challenges in achieving proper anatomical alignment of the fibula, which, if misaligned, can negatively impact the overall outcome of pilon fractures (5).

The utilization of circular external fixation, particularly the Ilizarov fixator technique, has emerged as a comprehensive therapeutic approach for these fractures. This method offers several advantages, including enhanced fracture stability, preservation of soft tissue integrity, and the facilitation of early rehabilitation (6). Despite these benefits, the literature indicates a lack of consensus regarding the

efficacy of circular external fixation in the management of distal tibial fractures, necessitating further research to establish evidence-based treatment protocols and improve patient care. Distal tibial fractures are often associated with high-energy impact and rotational forces, which not only affect the bone but also lead to concomitant soft tissue injuries such as sprains, contusions, and muscle strains (7, 8). These fractures pose significant treatment challenges due to the high risk of complications, including non-union, malunion, and infection. The choice of treatment modality significantly impacts the functional and clinical outcomes, with various therapeutic strategies being employed to minimize soft tissue injury and optimize fracture healing (9, 10).

Given the high rates of complications associated with different treatment modalities, the decision-making process in managing distal tibial fractures is critical. The use of circular external fixation is a method that aims to provide stability while preserving soft tissue, yet its effectiveness compared to other methods, such as intramedullary nailing or plate fixation, remains a topic of ongoing debate. The current study seeks to address this gap in the literature by evaluating the clinical and functional outcomes of circular external fixation in patients with distal tibial fractures. By conducting a prospective analysis, this study aims to provide valuable insights into the relative benefits of this technique, potentially influencing future clinical guidelines and improving long-term patient outcomes in orthopedic practice. The findings are expected to contribute significantly to the understanding of how circular external fixation can be optimized in the treatment of complex tibial fractures, particularly in minimizing complications and enhancing functional recovery (11).

2 Material and Methods

This prospective study was conducted from September 2023 to May 2024 at the Department of Orthopedics, Hayatabad Medical Complex, Peshawar, following approval from the hospital's ethical review board. The study was carried out in accordance with the ethical standards set by the Declaration of Helsinki. A total of sixty patients, aged 18 years or older, presenting with distal tibial fractures of various etiologies, were included in the study. Inclusion criteria required that patients had no significant comorbid conditions such as diabetes or pregnancy, and were below the age of 60 years. These criteria were established to minimize the influence of confounding factors on the study outcomes. All participants provided informed consent prior to their inclusion in the study.

Patients were initially assessed clinically and radiologically to confirm the diagnosis of distal tibial fractures, with additional assessment for associated injuries such as fibular fractures and soft tissue damage. The treatment involved the application of the Ilizarov fixator technique, a circular external fixation method, by an experienced orthopedic surgeon with more than five years of expertise in using this technique. The Ilizarov fixator was applied following standard surgical protocols, ensuring proper alignment and stabilization of the fracture. Postoperatively, patients were closely monitored for any complications, including infection, malunion, and nonunion.

Functional outcomes were assessed six months post-surgery using the Association for the Study and Application of Methods of Ilizarov (ASAMI) criteria, which categorizes outcomes as excellent, good, fair, or poor based on specific functional and radiological parameters. Pain levels were evaluated using the Visual Analog Scale (VAS), with patients being asked to rate their pain on a scale of 1 to 10 both preoperatively and postoperatively. This allowed for a comparative analysis of pain reduction following the procedure. Radiographic assessments were performed to evaluate the alignment, union, and any signs of malunion or nonunion.

Data were collected systematically and recorded in a standardized format. The collected data were then entered into SPSS version 25 for statistical analysis. Descriptive statistics were employed to summarize the demographic data, including age, gender, BMI, and comorbidities. The paired t-test was used to compare preoperative and postoperative VAS scores, with a significance level set at $p < 0.05$ to determine the statistical significance of pain reduction. The functional outcomes, categorized by ASAMI criteria, were presented as frequencies and percentages to provide a clear depiction of the distribution of outcomes among the study participants.

Throughout the study, efforts were made to ensure the accuracy and reliability of the data, with regular cross-checks and validation procedures in place. The study was designed to contribute to the existing body of knowledge on the management of distal tibial fractures, with a specific focus on the efficacy of circular external fixation(12-15).

3 Results

The study included sixty patients with distal tibial fractures treated using the Ilizarov circular external fixation technique. The mean age of the patients was 41.10 ± 12.74 years, with the majority being male (76.7%). The mean BMI of the cohort was 25.07 ± 1.88 kg/m². Comorbidities and lifestyle factors such as hypertension and smoking were also recorded, with 40.0% of patients being hypertensive and 36.7% identified as smokers. The demographic details and comorbidities are presented in **Table 1**.

Table 1: Demographics and Comorbidities of Patients

Variable	Frequency (n = 60)	Percentage (%)
Gender		
Male	46	76.7
Female	14	23.3
Hypertension		

Yes	24	40.0
No	36	60.0
Smoking		
Yes	22	36.7
No	38	63.3
Education Status		
Educated	26	43.3
Uneducated	34	56.7

The etiology of injuries varied, with the majority of cases resulting from road traffic accidents (51.7%), followed by falls (38.3%) and sports injuries (10%). The distribution of injury etiologies is depicted in **Table 2**.

Table 2: Etiology of Injury

Etiology	Frequency (n = 60)	Percentage (%)
Road Accidents	31	51.7
Fall	23	38.3
Sports Injury	6	10.0

The functional outcomes were assessed using the ASAMI score, which revealed that 63.3% of patients had an excellent outcome, 18.3% had a good outcome, 15.0% had a fair outcome, and 3.3% had a poor outcome. These outcomes are summarized in **Table 3**.

Table 3: Functional Outcomes Based on ASAMI Score

Outcome	Frequency (n = 60)	Percentage (%)
Excellent	38	63.3
Good	11	18.3
Fair	9	15.0
Poor	2	3.3

A significant reduction in pain levels was observed postoperatively, as measured by the Visual Analog Scale (VAS). The mean preoperative pain score was 7.47 ± 0.999, which decreased to 2.47 ± 0.982 postoperatively ($p = 0.0001$). The comparison of preoperative and postoperative pain scores is provided in **Table 4**.

Table 4: Comparison of Preoperative and Postoperative Pain Scores on VAS

Pain Score	Mean ± SD	p-value
Preoperative (VAS)	7.47 ± 0.999	0.0001
Postoperative (VAS)	2.47 ± 0.982	

The incidence of complications was minimal, with 81.7% of patients experiencing no complications. However, 13.3% of patients developed infections, 1.7% had malunion, and 3.3% experienced nonunion. The details of complications are outlined in **Table 5**.

Table 5: Postoperative Complications

Complication	Frequency (n = 60)	Percentage (%)
Infection	8	13.3
Malunion	1	1.7
Nonunion	2	3.3
No Complication	49	81.7

Overall, the results demonstrated that circular external fixation using the Ilizarov technique provided favorable functional and clinical outcomes for the majority of patients, with significant pain reduction and a relatively low rate of complications.

4 Discussion

The management of distal tibial fractures remains a significant challenge in orthopedic practice, particularly when addressing fractures associated with high-energy trauma. The findings of this study demonstrated that circular external fixation using the Ilizarov technique is a viable and effective treatment option, yielding favorable functional and clinical outcomes in a majority of patients. Specifically, the study revealed that 63.3% of patients achieved excellent outcomes, while 18.3% had good outcomes, with only a small percentage experiencing fair or poor outcomes. These results are consistent with those of previous studies, which have highlighted the efficacy of circular external fixation in managing complex tibial fractures, particularly in cases where soft tissue preservation is paramount (6, 14).

The significant reduction in pain observed in this study, as evidenced by the decrease in VAS scores from preoperative to postoperative assessments, underscores the effectiveness of the Ilizarov technique in alleviating discomfort associated with distal tibial fractures. This pain reduction aligns with findings from similar studies, which have reported notable improvements in pain management following the use of circular external fixation (15-17). The low incidence of complications, particularly nonunion and malunion, further supports the use

of this technique as a reliable option for achieving satisfactory fracture healing. The complication rates in this study were lower than those reported in studies involving other fixation methods, such as intramedullary nailing or plate fixation, which often present higher risks of infection, nonunion, and other adverse outcomes (12, 13).

However, the study is not without its limitations. One notable limitation is the relatively small sample size, which may limit the generalizability of the findings. Additionally, the study's follow-up period was restricted to six months, which, while sufficient for assessing initial outcomes, may not fully capture the long-term complications and functional status of the patients. Future studies with larger sample sizes and extended follow-up periods are recommended to provide a more comprehensive understanding of the long-term efficacy and potential complications associated with circular external fixation. Another limitation is the exclusion of patients with certain comorbidities, such as diabetes, which may affect the external validity of the results, particularly in populations with a higher prevalence of such conditions. The exclusion criteria, while necessary to control for confounding factors, may have resulted in a study population that does not fully represent the broader spectrum of patients with distal tibial fractures.

Despite these limitations, the study has several strengths. It was conducted prospectively, allowing for a systematic collection of data and minimizing recall bias. The use of a standardized outcome measure, the ASAMI score, provided a robust framework for evaluating functional outcomes, facilitating comparisons with other studies in the literature. Additionally, the involvement of an experienced surgeon with over five years of expertise in the Ilizarov technique likely contributed to the high success rates observed in this study. This highlights the importance of surgical expertise in achieving optimal outcomes with circular external fixation (16).

5 Conclusion

In conclusion, the study provided valuable insights into the effectiveness of circular external fixation in the management of distal tibial fractures. The technique demonstrated significant advantages in terms of functional outcomes, pain reduction, and a low incidence of complications. While the study's findings are promising, further research is needed to explore the long-term outcomes and to compare the efficacy of this technique with other treatment modalities. Given the high success rates observed in this study, circular external fixation should be considered a viable option for managing complex distal tibial fractures, particularly in cases where soft tissue preservation is a priority. Future research should also focus on optimizing patient selection criteria and refining surgical techniques to further enhance the outcomes associated with this approach.

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